U. S. FOREST SERVICE

RESEARCH NOTE NC-82

NORTH CENTRAL FOREST EXPERIMENT STATION, FOREST SERVICE—U.S. DEPARTMENT OF AGRICULTURE

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EFFECT OF WATERSHED COVER ON OVERLAND FLOW FROM A MAJOR STORM IN SOUTHWESTERN WISCONSIN[1]

ABSTRACT. — A runoff study in the Driftless Area showed that both total flow and peak rate of flow from a 3-hour, 4-inch rain were strongly affected by the watershed cover. Peak flows ranged from 2.42 inches per hour for alfalfa meadow to 0.010 inch per hour for undisturbed forest. The timing of flow on open-land and forested watersheds was surprisingly similar.
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Flash floods from thunderstorms are a common occurrence in southwestern Wisconsin's rugged Driftless Area. Because of the deep soils and porous bedrock, rainfall that infiltrates the soil does not normally contribute to flood flows. Floods result only when restricted infiltration produces overland flow. Because soil cover largely determines how fast the soil takes up water (or yields overland flow), land use has a strong influence on flash floods in this area.

Early work by Bates and Zeasman (1930) and a later study by Hays, McCall, and Bell (1949) showed that relatively undisturbed forest land in the Driftless Area yielded little overland flow. Flood source studies now being conducted on the Coulee Experimental Forest near La Crosse have strengthened this general observation (Curtis 1966) and are also providing new information for other watershed conditions. A high-intensity storm that hit the experimental forest in June 1968 gave us an excellent chance to compare flows from six different cover conditions: undisturbed, logged, and grazed forest, alfalfa meadow, old field, and "goat prairie."

The Study Watersheds

Undisturbed forest. — As used here, "undisturbed" means *relatively* undisturbed. The forest cover is pole-to-sawtimber-size oak-hickory, typical of the high-graded farm woods in the area. One of two watersheds classed as undisturbed had been selectively logged (logger's choice) in 1960, and both had been pastured for many years until 1960.

Logged forest. — The logged watershed was clear cut in the fall of 1966 as part of a timber management study. Two-thirds of the watershed was logged with a minimum of disturbance to the soil.

Grazed forest. — The grazed watershed has a forest cover in poor condition and some patches of prairie. It is also traversed by a tractor road, which contributes to overland flow. The area has been used as pasture for many years, and because of the condition of the forest cover and the amount of exposed soil it is an extreme example of grazed forest.

[1] *This research was done in cooperation with the Wisconsin Department of Natural Resources.*

Alfalfa meadow. — These watersheds were in third-year alfalfa that had not yet been cut at the time of the storm.

Old field. — The medium-density cover on this area consists of Kentucky bluegrass, wild carrot, goldenrod, and other herbaceous plants. This area had been cropped and pastured for many years until 1960.

Goat prairie. — The term "goat prairie" is a local name given to the steep, rocky, south-facing, natural prairie slopes that are a distinctive part of the Driftless Area landscape. The goat prairie studied has a thin cover of big bluestem, other native grasses and forbs, and Kentucky bluegrass. It is on a steep (50 percent) slope that had been grazed for many years until 1960.

The forested watersheds are single ridge-to-valley topographic units with sharp divides. Size ranges from 20 to 60 acres, and the average slope is about 40 percent. The meadow and old-field watersheds are segments of ridgetop fields that lie above forested slopes. The segments are bounded by natural divides on the sides and top but are terraced at the bottom to cut off downslope runoff and channel it to the flume. Size ranges from 1.5 to 2.0 acres and slope averages about 15 percent. The goat-prairie watershed is a long, narrow strip of slope 1.3 acres in area bounded by a ridge at the top and a terrace at the bottom. The artificial terraces might affect rate, but not volume, of flow. Thus, the open-land watersheds might better be described as natural runoff plots. However, in this area of intermixed forest, field, and prairie, they are as close as we can come to actual watersheds in a single open-land use.

Flow from all areas was measured with H-type flumes equipped with water-level recorders. The runoff measured was entirely overland flow. None of the watersheds produces either base or seepage flow, even during heavy rainfall periods.

The Storm

The rain fell between 12:10 a.m. and 5:10 a.m. on June 21, 1968. Total rainfall was 4 inches, of which 3.8 inches fell in the first 2 hours and 15 minutes. Maximum amounts that fell in various time intervals during the storm and their probable recurrence according to the Rainfall Frequency Atlas of the United States (U.S. Department of Commerce, Weather Bureau 1961) are as follows:

Time interval (minutes)	*Rainfall amount* (inches)	*Rainfall frequency* (years)
15	0.90	.....
30	1.45	5
60	1.85	5
120	3.00	50
180	4.00	100

Total storm rainfall was surprisingly uniform on the experimental forest. The amounts caught by two recording gages 2 miles apart differed by only 0.04 of an inch, and the two charts showed identical intensity patterns.

Watershed Response

Both total and peak flows from study watersheds were strongly affected by land use (fig. 1). The peak flow of 2.4 inches per hour from meadow was 1.8 times the peak from old field, 5 times the peak from grazed forest, and 32 times the peak from logged forest. Total flow followed a similar pattern. The small flow from goat prairie upsets the view held by some that these steep, sparsely vegetated slopes are high runoff producers. Although the flow from old field was high compared with the flow from any of the forest conditions, it would be low compared with flows from tilled cropland. Runoff from meadow is generally much lower than from tilled land. Thus, simply idling cropland with no further treatment reduces runoff substantially.

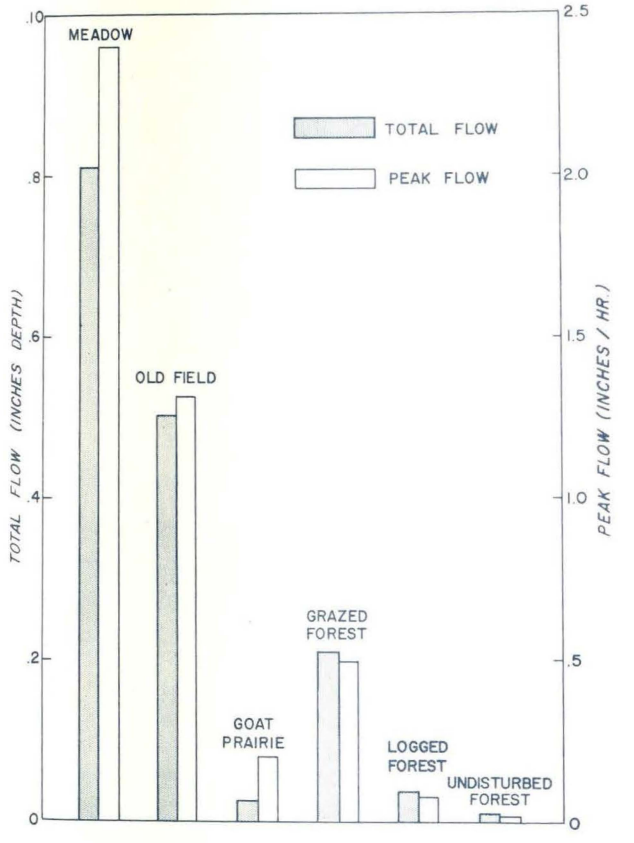

Figure 1.— Total and peak flows for watersheds in different cover conditions.

Although grazed forest runoff was high compared to logged forest, undisturbed forest, and goat prairie runoff, it was low compared to meadow runoff. Because the grazed forest watershed studied probably represents an extreme condition for grazed forest land, it appears that forest-land pastures are not an important source of flood runoff.

Considering the differences in size and topographic makeup between the open-land and forested watersheds, timing of flow was surprisingly similar on both types. Runoff began on all the open-land watersheds 60 minutes after it began to rain, and on the forested watersheds just a few minutes later. However, flows on the alfalfa meadow, old field, and grazed forest watersheds showed much greater fluctuation with short bursts of high-intensity rain than flows on the other watersheds.

This difference in watershed response is shown by the hydrographs for a meadow and an undisturbed forest watershed (fig. 2). All

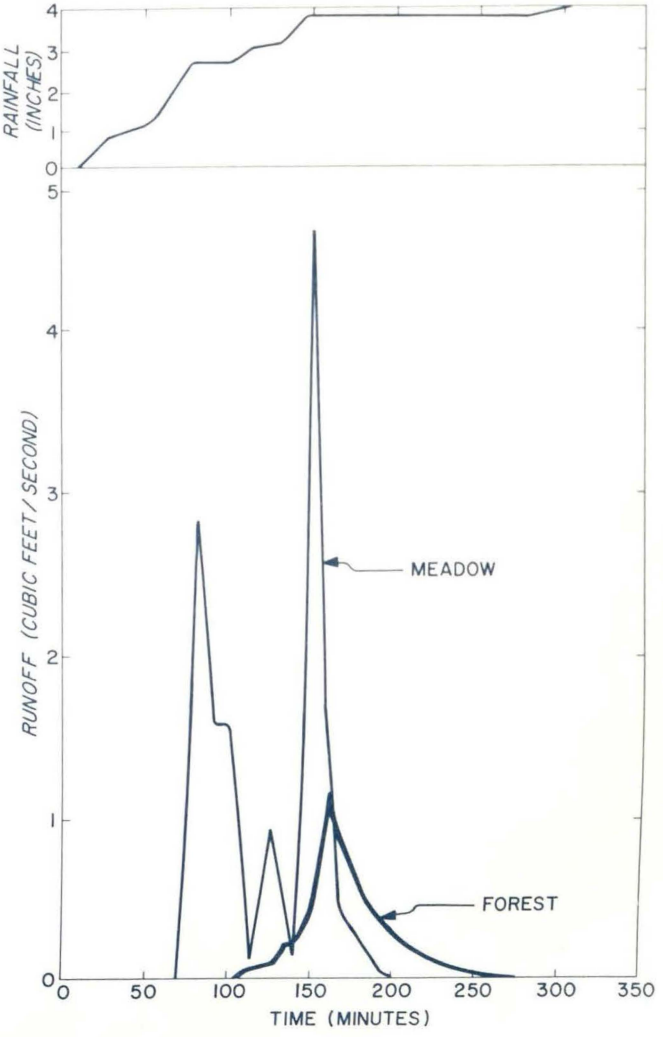

Figure 2. — Mass rainfall curve and hydrographs for a meadow and an undisturbed forest watershed. Note that hydrograph plots are in cubic feet per second. Meadow watershed area is 2 acres, forest watershed area is 61 acres.

watersheds except one (undisturbed forest) had two distinct flow peaks; the timing of these peaks was about the same on all watersheds. The second peak was higher except on the grazed forest watershed and on one of the undisturbed forest watersheds. The cause of this difference in watershed response to the storm is not known, but is probably related to some inherent watershed characteristic.

Although the flows cited here may not be strictly comparable because of differences in the size, shape, soils, and topography of the watersheds, the data do show the relative contribution of some common land uses to rainstorm floods in the Driftless Area.

Literature Cited

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